SEMI-ANNUAL REPORT
NASA CONTRACT NAS5-31368
FOR MODIS TEAM MEMBER STEVEN W. RUNNING
ASSOC. TEAM MEMBERS E.RAYMOND HUNT, RAMAKRISHNA R. NEMANI
15 JULY 1993

PRE-LAUNCH TASKS PROPOSED IN OUR CONTRACT OF DECEMBER 1991

We propose, during the pre-EOS phase to: (1) develop, with other MODIS Team Members, a means of discriminating different major biome types with NDVI and other AVHRR-based data. Natural lifeform types of interest are broadleaf and coniferous forests (boreal-temperate-tropical etc discriminated by climate) chaparral-shrubland, grassland. Discrimination will be based on canopy bi-directional reflectance properties, seasonal phenology and surface climate. (2) develop a simple ecosystem process model for each of these biomes, BIOME-BGC based on the logic of the current FOREST-BGC; (3) relate the seasonal trend of weekly composite NDVI to vegetation phenology and temperature limits to develop a satellite defined growing season for vegetation; and (4) define physiologically based energy to mass conversion factors for carbon and water for each biome.

Our final core at-launch product will be simplified, completely satellite driven biome specific models for ET and PSN based on this modified ΣNDVI logic. These algorithms will be in MODISDIS before launch. We will build these biome specific satellite driven algorithms using a family of simple ecosystem process models as calibration models, collectively called BIOME-BGC, and establish coordination with an existing network of ecological study sites in order to test and validate these products. Field datasets will then be available for both BIOME-BGC development and testing, use for algorithm developments of other MODIS Team Members, and ultimately be our first test point for

MODIS land vegetation products upon launch. We will use field sites from the National Science Foundation Long-Term Ecological Research network, and develop Glacier National Park as a major site for intensive validation.

OBJECTIVES:

We have defined the following near-term objectives for the first two years of our MODIS contract based on the long term objectives proposed above.

1) Organization of an EOS ground monitoring network with collaborating U.S. and international science agencies.

2) Compiling a journal article summarizing the products planned by MODLAND during the EOS era, for distribution throughout the scientific community.

3) As development of the MODIS Surface resistance product, mapping the seasonal changes in surface moisture status over the continental US from NOAA/AVHRR.

4) Develop improved algorithms for estimating LAI for different biome types from AVHRR data.

5) Implementation of Regional Hydro-Ecological Simulation System (RHESSys) to all of North America.

6) Development of a generalized ecosystem process model, BIOME-BGC, for the simulation of the carbon, water and nitrogen cycles for different biomes.

7) Use BIOME-BGC to estimate continental net primary production (NPP) from AVHRR-NDVI data.

8) Develop advanced logic for landcover classification using carbon cycle simulations from BIOME-BGC.

WORK ACCOMPLISHED:

OBJECTIVE 1: Organization of an EOS ground monitoring network with collaborating U.S. and international science agencies.

EOS-LTER

Plans are continuing with the LTER scientists, sponsored by the National Science Foundation, to use the LTER's in the United States as an EOS ground monitoring network. A meeting was held at Goddard on March 20-22 furthering the plans. A report of the meeting in New Mexico on these plans has been published by the LTER office (Appendix 1).

Global Terrestrial Observing System (GTOS)

SWRunning has been nominated to the IGBP-GTOS. This newly proposed global monitoring network may prove to be an important avenue for developing a coordinated EOS ground monitoring network. The first GTOS meeting, scheduled for June 1993, has been postponed.

BOREAS proposal

We plan for BOREAS to provide us with a wealth of field data for algorithm testing and validation. Dr. Joseph Coughlan (NASA-AMES) attended the BOREAS Science Team site visit in May 1993 on our behalf.

IGBP Biospheric Aspects of the Hydrologic Cycle (BAHC)

As vice-chair of BAHC, SWRunning has responsibility for developing and executing the science agenda of this core IGBP project. Many of the IGBP science objectives are tightly related to EOS science objectives, and are being executed by many of the same people. SWR visited the BAHC office in Berlin on July 5-6, 1993, and gave a seminar on global modelling.

IGBP Global Change and Terrestrial Ecosystems (GCTE)

ERHunt attended a GCTE meeting in Seattle, Washington (April 12-16, 1993) for the purpose of starting a new focus on forest

ecosystems

OBJECTIVE 2: Journal article summarizing the products planned by MODLAND during the EOS era.

The MODLAND manuscript was submitted in March 1993 and is still under review.

OBJECTIVE 3: Development of the MODIS Surface resistance product.

Work on this product is continuing. A journal article on our work appeared in the Journal of Applied Meteorology in March 1993 (Appendix 2).

OBJECTIVE 4: Develop improved algorithms for estimating LAI from AVHRR data.

Based on recent work from spectral-mixture models and radiative transfer models, NDVI may be more related to fraction of vegetation cover rather than LAI. By determining the maximum LAI for a vegetation class from other data, then LAI may be determined from fraction cover. Figure 1 shows our most recent version of a global LAI product.

OBJECTIVE 5: Implementation of Regional Hydro-Ecological Simulation System (RHESSys) to all of North America.

BIOME-BGC was revised to run under the UNIX operating system for workstations. The code was optimized and incorporated into the Global Ecological Simulation System (GESSys). C. David Keeling and Steve Piper providing 1987 daily climate data at a 1° latitude by 1° longitude resolution. Ralf Otto, visiting from the University of Frankfurt (now Johann Wolfgang Goethe Universitaet), generated data layers for soil water holding capacity from Zobler's dataset (Figure 2). Ralf Otto and ERHunt developed a landcover classification based on Matthew's dataset (Figure 3).

We have finished preliminary simulations and estimated global net primary production to be about 45 Gt of carbon (Figure 4).

OBJECTIVE 6: Development of a generalized ecosystem process model, BIOME-BGC.

BIOME-BGC was revised with new variables and algorithms for soil biogeochemical processes and stable carbon isotope discrimination during photosynthesis. The isotopic ratio $^{13}C/^{12}C$ of vegetation may be one best parameters available for validating BIOME-BGC, because it integrates water use efficiency over a year. Also, $^{13}C/^{12}C$ may be used as an atmospheric tracer of the uptake and release of carbon by the oceans and terrestrial biosphere.

A first version of a user's guide was written to document BIOME-BGC (Appendix 3).

OBJECTIVE 7: Use BIOME-BGC to estimate continental net primary production (NPP) from AVHRR-NDVI data.

We determined from BIOME-BGC that much of the variation in ε for forests may be attributed to the large mass of living wood. We are collaborating with Canadian scientists to determine if ERS-1 or JERS-1 synthetic aperture radar (SAR) may be used to determine woody biomass. A symposium article has been published (listed in the references)

OBJECTIVE 8: Develop advanced logic for landcover classification using carbon cycle simulations from BIOME-BGC

During SWR's sabbatical leave at the University of Lund, Sweden with Dr. I. Colin Prentice, he spent considerable time developing a global landcover classification logic that can be remotely sensed. These ideas were written into a manuscript submitted to the journal, Ambio, as part of a special issue from the IGBP meeting in Ensenada, Mexico. Manuscript is attaches as

Appendix 4.

ANTICIPATED FUTURE ACTIONS

EOS Ground Monitoring Network

1) SWR plans to attend the LTER All-scientists meeting in Estes Park, Colorado September 18-24.

2) The first meeting of GTOS will be scheduled in the next 6 months.

MODLAND Participation in BOREAS

SWR will attend the next BOREAS Science team meeting, scheduled for October, 1993.

MODLAND Journal Article

The final revisions for the MODLAND paper should be completed in the next 6 months.

Surface Resistance

1) Determine if EDC bi-weekly composite data can be used for generating the Ts/NDVI relations. What are the consequences of generating the composite AVHRR data based on highest surface temperature instead of highest NDVI?

2) Formulate methodology to normalize the Ts/NDVI relations for local meteorological conditions so that day-to-day and region-to-region relationships can be compared.

RHESSys Simulations

1) Determine the maximum LAI for various biomes.

2) Map soil water holding capacities at continental scales using the climate-soil-leaf area hydrologic equilibrium approach. First test will be Montana state map.

3) Complete implementation of RHESSys at 1 km scale for the continental US.

Net Primary Production From NDVI Data

1) Field work is planned for July 10-26 by ERH to test the NDVI-APAR approach using SAR data to estimate woody biomass.

Land Cover

1) SWR will be working with Tom Loveland of the Eros DAC to test the new remote-sensing based landcover logic proposed in the Ambio paper. A more complete manuscript on this topic is being completed to submit for the special ISLSCP issue of Remote Sensing of Environment resulting from the June 1992 ISLSCP Americas meeting in Columbia, Maryland.

2) We plan to write the ATBD documents for an LAI/APAR product and photosynthesis/net primary production product in the next 2 months.

PROBLEMS/CORRECTIVE ACTIONS

None

MEETINGS ATTENDED in 1993 (attendee initials included)

The Third IGBP Scientific Advisory Council and Symposium, Ensenada,
Mexico, 25-29 January 1993. SWR
UNEP Classification Scheme Workshop, January 1993. LL Pierce
MODIS Science Team meeting, March 1993. SWR
EOS/LTER Workshop, March 1993. SWR.
IGBP-GCTE New Focus on Forest Ecosystems, April 1993. ERH
SCOPE Model Comparison Workshop, London, April 1993. SWR.
SCOPE Global Change Workshop, Washington DC, May 1993. ERH
EPRI Global Model Comparison Workshop, Woods Hole, July 1993. RRN

PUBLICATIONS

Hunt, E. R., Jr. 1993. BIOME-BGC: A User's Guide.

Nemani, R.R., L.L. Pierce, S.W. Running and S.N. Goward. 1993. Developing satellite derived estimates of surface moisture status. Journal of Applied Meteorology, 32: 548-557.

Nemani, R.R., L.L. Pierce, L.E. Band and S.W. Running. 1993. Forest Ecosystem Processes at the watershed scale: Sensitivity to remotely sensed leaf area index observations. Int. Journal of Remote Sensing, (in press)

Nemani, R.R., S.W. Running, L.E. Band and D.L. Peterson. 1993. Regional Hydro-Ecological Simulation System (RHESSys): An illustration of the integration of ecosystem models in a GIS. In: Integrating GIS and environmental modeling, Eds: M. Goodchild, B. Parks and L. Steyaert, Oxford, London (in press).

Running, S.W., C. Justice, V. Salomonson, D. Hall, J. Barker, Y. Kaufmann, A. Strahler, A. Huete, J.-P. Muller, V. Vanderbuilt, Z. M. Wan, P. Teillet, and D. Carnegie. 1993. Terrestrial remote sensing science and algorithms planned for EOS/MODIS. International Journal of Remote Sensing (submitted).

Running, S.W., Loveland, T.R., and L.L. Pierce. 1993. A remote sensing based vegetation classification logic for use in global biochemical models. Ambio (enclosed).

Ryan, M.G., E.R. Hunt Jr., R.E. McMurtrie, G.I. Ågren, J.D. Aber, A.D. Friend, E.B. Rastetter, W. J. Parton, R.J. Raison, and

S. Linder. 1993. Comparing models of ecosystem function for coniferous forests. I. Model description and validation. In SCOPE Volume "Effects of Climate Change on Production and Decomposition in Coniferous Forests and Grasslands", edited by J.M. Melillo, G.I. Ågren, and A. Breymeyer. (in press).

Ryan, M.G., R.E. McMurtrie, G.I. Ågren, E.R. Hunt Jr., J.D. Aber, A.D. Friend, E.B. Rastetter, and W.J.Parton. 1993. Comparing models of ecosystem function for coniferous forests. II. Predictions of response to changes in atmospheric [CO2] and climate. In SCOPE Volume "Effects of Climate Change on Production and Decomposition in Coniferous Forests and Grasslands", edited by J.M. Melillo, G.I. Ågren, and A. Breymeyer. (in press)

Wilson, B.A., S.E. Franklin, M.B. Lavigne, and E.R. Hunt, Jr. 1993. Estimating balsam fir forest stand conditions using ERS-1 SAR data. 16th Canadian Symposium on Remote Sensing. pp. 295-300.

Zheng, D., E. R. Hunt, Jr., and S. W. Running. 1993. A daily soil temperature model derived from air temperature and precipitation for continental applications. Climate Research. (in press).

Figures

Figure 1. Global leaf area index estimates derived from long-term climate, soil texture and GVI data. First, leaf area index of a plant/clump/tree (LAIp) was derived using the hydrologic equilibrium between climate, soil and leaf area. Then, the LAIp was scaled to the canopy Leaf area index using estimates of fractional vegetation cover derived from the GVI data.

Figure 2. Estimated available soil water holding capacity from soil texture and potential vegetation. We assigned specific Soil Conservation Service texture classes to the Zobler soil texture database available from Kineman and Ohrenschall (1992 NOAA/EPA Global Ecosystems Database version 1.0 on CD-ROM). From texture, volumetric water content at field capacity was calculated. Soil depth was estimated from Matthews Vegetation Database (Kineman and Ohrenschall 1992). From soil depth and volumetric water content at field capacity, the available water content was estimated.

Figure 3. Global lifeform map from Matthew's potential vegetation and cultivation intensity maps (from Kineman and Ohrenschall 1992). We assigned Matthews vegetation classes to one of five lifeforms. When cultivation intensity was 50% or greater, we assigned that pixel as a C3 grassland, except for the US cornbelt region and African sorghum region, which were assigned as C4 grasslands.

Figure 4. Global net primary production estimated from a Global Ecosystem Simulation System (GESSys). GESSys is a modeling system, consisting of an ecosystem model (BIOME-BGC) and a climate simulation model (CLIMSIM), designed to compute and map daily carbon and water fluxes at 1x1 degree scale. GESSys

estimates of global NPP (45 Gt) were less than earlier estimates (55 Gt), possibly due to our actual estimates of vegetation compared to potential vegetation used by others.

Appendix 1

Vande Castle, J. R. and R. H. Waring (eds) 1993. LTER/NASA Remote Sensing Workshop. Distributed by the Long-Term Ecological Research Network Office, College of Forest Resources, AR-10, University of Washington, Seattle, WA 98195.

Appendix 2

Nemani, R.R., L.L. Pierce, S.W. Running and S.N. Goward. 1993. Developing satellite derived estimates of surface moisture status. Journal of Applied Meteorology, 32: 548-557.

Appendix 3

Hunt, E. Raymond, Jr. 1993. BIOME-BGC: User's Guide

Appendix 4

Running, S.W., Loveland, T.R., and L.L. Pierce. 1993. A remote sensing based vegetation classification logic for use in global biochemical models. Ambio (submitted).